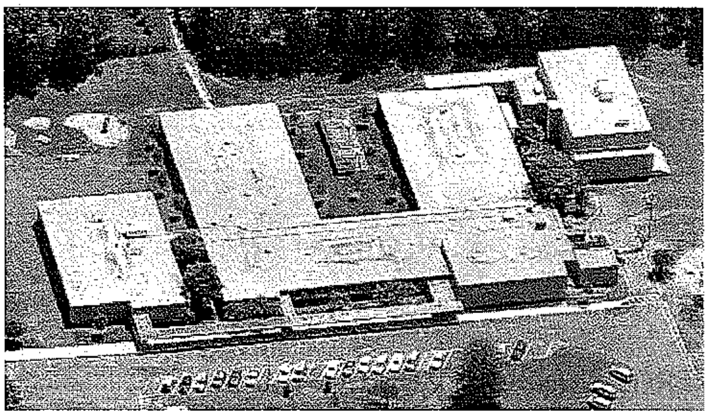

ENERGY AUDIT – FINAL REPORT

BRIDGEWATER RARITAN
VAN HOLTEN ELEMENTARY

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I. EXECUTIVE SUMMARY

This report presents the findings of the energy audit conducted for:

Bridgewater Raritan
Van Holten Elementary School
460 Van Holten Road
Bridgewater, NJ 08807

Contact Person:	Connie Coriell
Title:	Energy Efficiency Coordinator

This audit is performed in connection with the New Jersey Clean Energy - Local Government Energy Audit Program. The energy audit is conducted to promote the mission of the office of Clean Energy, which is to use innovation and technology to solve energy and environmental problems in a way that improves the State's economy. This can be achieved through the wiser and more efficient use of energy.

The annual energy costs at this facility are as follows:

Electricity	$ 50,511
Natural Gas	$ 57,979
Total	$ 108,490

The potential annual energy cost savings for each energy conservation measure (ECM) and renewable energy measure (REM) are shown below in Table 1. <u>Be aware that the ECM's and REM' are not additive because of the interrelation of some of the measures.</u> This audit is consistent with an ASHRAE level 2 audit. The cost and savings for each measure is ± 20%. The evaluations are based on engineering estimations and industry standard calculation methods. More detailed analyses would require engineering simulation models, hard equipment specifications, and contractor bid pricing.

Table 1
Financial Summary Table

ENERGY CONSERVATION MEASURES (ECM's)					
ECM NO.	**DESCRIPTION**	**NET INSTALLATION COST[A]**	**ANNUAL SAVINGS[B]**	**SIMPLE PAYBACK (Yrs)**	**SIMPLE LIFETIME ROI**
ECM #1	Lighting Controls	$5,760	$1,612	3.6	319.8%
ECM #2	Window Replacement	$454,950	$8,547	53.2	-53.0%
ECM #3	Window AC Unit Replacement	$420	$44	9.5	4.8%
ECM #4	H&V Control Valve and T-Stat Replacements	$70,000	$4,520	15.5	-3.1%
ECM #5	Boiler Controls	$25,000	$3,458	7.2	107.5%
ECM #6	DDC Conrols	$137,500	$6,888	20.0	-24.9%
ECM #7	Pump VFDs	$5,150	$1,616	3.2	370.7%
ECM #8	ECM #4, & ECM #7	$75,150	$6,136	12.2	22.5%
ECM #9	Condensing Boiler	$70,000	$8,963	7.8	220.1%
ECM #10	ECM #4, ECM #7, & ECM #9	$145,150	$15,099	9.6	56.0%
RENEWABLE ENERGY MEASURES (REM's)					
ECM NO.	**DESCRIPTION**	**NET INSTALLATION COST**	**ANNUAL SAVINGS**	**SIMPLE PAYBACK (Yrs)**	**SIMPLE LIFETIME ROI**
REM #1	Solar PV System	$2,341,170	$148,118	15.8	58.2%

Notes: A. Cost takes into consideration applicable NJ Smart StartTM incentives.
B. Savings takes into consideration applicable maintenance savings.

The estimated demand and energy savings for each ECM and REM is shown below in Table 2. The descriptions in this table correspond to the ECM's and REM's listed in Table 1.

Table 2
Estimated Energy Savings Summary Table

ENERGY CONSERVATION MEASURES (ECM's)				
		ANNUAL UTILITY REDUCTION		
ECM NO.	DESCRIPTION	ELECTRIC DEMAND (KW)	ELECTRIC CONSUMPTION (KWH)	NATURAL GAS (THERMS)
ECM #1	Lighting Controls	0.0	11,275	0
ECM #2	Window Replacement	0.0	0	5,814
ECM #3	Window AC Unit Replacement	0.4	311	0
ECM #4	H&V Control Valve and T-Stat Replacements	0.0	0	3,124
ECM #5	Boiler Controls	0.0	0	2,352
ECM #6	DDC Conrols	0.0	0	4,686
ECM #7	Pump VFDs	0.0	11,301	0
ECM #8	ECM #4, & ECM #7	0.0	11,301	3,124
ECM #9	Condensing Boiler	0.0	0	6,097
ECM #10	ECM #4, ECM #7, & ECM #9	0	11,301	9,221

RENEWABLE ENERGY MEASURES (REM's)				
		ANNUAL UTILITY REDUCTION		
ECM NO.	DESCRIPTION	ELECTRIC DEMAND (KW)	ELECTRIC CONSUMPTION	NATURAL GAS (THERMS)
REM #1	Solar PV System	260.0	300,443	0.0

Concord Engineering Group (CEG) recommends proceeding with the implementation of all ECM's that provide a calculated simple payback at or under ten (10) years. The following Energy Conservation Measures are recommended for the facility:

- **ECM #1:** Lighting Controls
- **ECM #3:** Window AC Unit Replacements
- **ECM #5:** Boiler Controls
- **ECM #9:** Condensing Boiler
- **ECM #10:** H&V Control Valve and T-Stat Replacement, Pump VFD, with Condensing Boiler

Van Holten Primary School is a low to moderate energy consumer compared to average commercial buildings due to the building's limited area with central cooling. When compared to other elementary schools, this facility's EUI rating is approximately 15% (The percent of similar buildings in the region less efficient than this building.) The cooling system in the addition is in good condition and energy efficient. The primary reason for the building's rating is due to the heating system. The lack of system control is responsible for substantial wasted heat energy each year. Implementation of the ECMs that include a boiler controls, control valve & thermostat replacements, and Pump VFDs could save significant operating costs each year.

The boilers are the heart of the building's heating system. Efficiency improvements on the central plant will directly lower the overall building heating cost by the increase in system efficiency. The condensing boiler installation is a large enough increase in overall boiler efficiency to provide a simple payback within 10 years. This option is highly recommended for the facility.

Pump VFDs provide a very quick payback if implemented with an ECM that includes replacing all control valves in the heating hot water system. The combination of the control valve and T-stat replacement, condensing boiler and VFD drives on the heating water pumps could save $15,099 in operating cost per year. These ECMs together pay back under 10 years, and save significant energy. These ECMs as a combination are recommended for the facility.

Lighting throughout the facility is among the most efficient forms of interior lighting available today. The main area for improvement with the lighting system is automatic control. The system could benefit from occupancy sensors which automatically turn off lights when a space is unoccupied. This conservation measure in addition with continuing district wide education on energy savings could save an additional 10% on lighting energy, approximately $1,600 per year. This ECM is highly recommended and a simple retrofit that pays back quickly.

Another contributor of this building's energy consumption is computer use. Computers are becoming a major component of energy use in buildings. Minimizing computer energy is an important part of reducing a building's overall energy use. Computers set to sleep or hibernate with monitors set to turn off when not in use requires almost zero energy (approximately 3

Watts.) Desktop computers left on with monitors on or in screen saver mode use approximately 150 Watts continuously. It is important to set all computers to hibernate or sleep when not being used, despite the extra time needed to re-boot when resuming work. When new computers are purchased to replace old computers, consider machines that have energy saving features and reduced operating energy use.

Some ECMs have long paybacks and unjustified installations. These ECMs such as window replacements and DDC controls do not appear economically suited for the building. It is important to understand that the ECM calculations and payback estimate is the time it would take for the energy savings to fully fund the installation cost of the improvement. In many cases with equipment changes it is very difficult to have the installation paid for entirely by the energy savings. Therefore when replacing old equipment due to end of life cycle and reliability needs, it is highly recommended to invest in energy efficient systems.

In addition to the ECMs, there are maintenance and operational measures that can provide energy savings and immediate benefit. The ECMs listed above represent investments that can be made to the facility which are justified by the savings seen overtime. However, the maintenance items and small operational improvements below are typically achievable with on site staff or maintenance contractors and in turn have the potential to provide substantial operational savings compared to the costs associated. The following are recommendations which should be considered a priority in achieving an energy efficient building:

1. Chemically clean the condenser and evaporator coils periodically to optimize efficiency. Poorly maintained heat transfer surfaces can reduce efficiency 5-10%.
2. Maintain all weather stripping on entrance doors.
3. Clean all light fixtures to maximize light output.
4. Provide frequent air filter changes to decrease overall system power usage and maintain better IAQ.
5. Set all computers to automatically sleep or hibernate with monitors set to turn off, NOT run in screen saver mode.

II. INTRODUCTION

The comprehensive energy audit covers the 52,400 square foot Crim Elementary School, which includes: classrooms, multi-purpose room, gymnasium, office administration area and support spaces.

Electrical and natural gas utility information is collected and analyzed for one full year's energy use of the building. The utility information allows for analysis of the building's operational characteristics; calculate energy benchmarks for comparison to industry averages, estimated savings potential, and baseline usage/cost to monitor the effectiveness of implemented measures. A computer spreadsheet is used to calculate benchmarks and to graph utility information (see the utility profiles below).

The Energy Use Index (EUI) is established for the building. Energy Use Index (EUI) is expressed in British Thermal Units/square foot/year (BTU/ft^2/yr), which is used to compare energy consumption to similar building types or to track consumption from year to year in the same building. The EUI is calculated by converting the annual consumption of all energy sources to BTU's and dividing by the area (gross square footage) of the building. Blueprints (where available) are utilized to verify the gross area of the facility. The EUI is a good indicator of the relative potential for energy savings. A low EUI indicates less potential for energy savings, while a high EUI indicates poor building performance therefore a high potential for energy savings.

Existing building architectural and engineering drawings (where available) are utilized for additional background information. The building envelope, lighting systems, HVAC equipment, and controls information gathered from building drawings allow for a more accurate and detailed review of the building. The information is compared to the energy usage profiles developed from utility data. Through the review of the architectural and engineering drawings a building profile can be defined that documents building age, type, usage, major energy consuming equipment or systems, etc.

The preliminary audit information is gathered in preparation for the site survey. The site survey provides critical information in deciphering where energy is spent and opportunities exist within a facility. The entire site is surveyed to inventory the following to gain an understanding of how each facility operates:

- Building envelope (roof, windows, etc.)
- Heating, ventilation, and air conditioning equipment (HVAC)
- Lighting systems and controls
- Facility-specific equipment

The building site visit is performed to survey all major building components and systems. The site visit includes detailed inspection of energy consuming components. Summary of building occupancy schedules, operating and maintenance practices, and energy management programs provided by the building manager are collected along with the system and components to determine a more accurate impact on energy consumption.

III. METHOD OF ANALYSIS

Post site visit work includes evaluation of the information gathered, researching possible conservation opportunities, organizing the audit into a comprehensive report, and making recommendations on HVAC, lighting and building envelope improvements. Data collected is processed using energy engineering calculations to anticipate energy usage for each of the proposed energy conservation measures (ECMs). The actual building's energy usage is entered directly from the utility bills provided by the owner. The anticipated energy usage is compared to the historical data to determine energy savings for the proposed ECMs.

It is pertinent to note, that the savings noted in this report are not additive. The savings for each recommendation is calculated as standalone energy conservation measures. Implementation of more than one ECM may in some cases affect the savings of each ECM. The savings may in some cases be relatively higher if an individual ECM is implemented in lieu of multiple recommended ECMs. For example implementing reduced operating schedules for inefficient lighting will result in a greater relative savings. Implementing reduced operating schedules for newly installed efficient lighting will result in a lower relative savings, because there is less energy to be saved. If multiple ECM's are recommended to be implemented, the combined savings is calculated and identified appropriately.

ECMs are determined by identifying the building's unique properties and deciphering the most beneficial energy saving measures available that meet the specific needs of the facility. The building construction type, function, operational schedule, existing conditions, and foreseen future plans are critical in the evaluation and final recommendations. Energy savings are calculated base on industry standard methods and engineering estimations. Energy consumption is calculated based on manufacturer's cataloged information when new equipment is proposed.

Cost savings are calculated based on the actual historical energy costs for the facility. Installation costs include labor and equipment costs to estimate the full up-front investment required to implement a change. Costs are derived from Means Cost Data, industry publications, and local contractors and equipment suppliers. The NJ Smart Start Building® program incentives savings (where applicable) are included for the appropriate ECM's and subtracted from the installed cost. Maintenance savings are calculated where applicable and added to the energy savings for each ECM. The life-time for each ECM is estimated based on the typical life of the equipment being replaced or altered. The costs and savings are applied and a simple payback, simple lifetime savings, and simple return on investment are calculated. See below for calculation methods:

ECM Calculation Equations:

$$Simple\ Payback = \left(\frac{Net\ Cost}{Yearly\ Savings}\right)$$

$$Simple\ Lifetime\ Savings = (Yearly\ Savings \times ECM\ Lifetime)$$

$$Simple\ Lifetime\ ROI = \frac{(Simple\ Lifetime\ Savings - Net\ Cost)}{Net\ Cost}$$

$$Lifetime\ Maintenance\ Savings = (Yearly\ Maintenance\ Savings \times ECM\ Lifetime)$$

$$Internal\ Rate\ of\ Return = \sum_{n=0}^{N}\left(\frac{Cash\ Flow\ of\ Period}{(1+IRR)^n}\right)$$

$$Net\ Present\ Value = \sum_{n=0}^{N}\left(\frac{Cash\ Flow\ of\ Period}{(1+DR)^n}\right)$$

Net Present Value calculations based on Interest Rate of 3%.

IV. HISTORIC ENERGY CONSUMPTION/COST

A. Energy Usage / Tariffs

The energy usage for the facility has been tabulated and plotted in graph form as depicted within this section. Each energy source has been identified and monthly consumption and cost noted per the information provided by the Owner.

The electric usage profile represents the actual electrical usage for the facility. Jersey Central Power & Lighting (JCP&L) provides electricity to the facility under their GSS rate structure. The electric utility measures consumption in kilowatt-hours (KWH) and maximum demand in kilowatts (KW). One KWH usage is equivalent to 1000 watts running for one hour. One KW of electric demand is equivalent to 1000 watts running at any given time. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges. Rates used in this report reflect the historical data received for the facility.

The gas usage profile shows the actual natural gas energy usage for the facility. Public Service Electric and Gas (PSE&G) provides natural gas to the facility under their LVG rate structure. The gas utility measures consumption in cubic feet x 100 (CCF), and converts the quantity into Therms of energy. One Therm is equivalent to 100,000 BTUs of energy.
The overall cost for utilities is calculated by dividing the total cost by the total usage. Based on the utility history provided, the average cost for utilities at this facility is as follows:

Description	Average
Electricity	14.3¢ / kWh
Natural Gas	$1.47 / Therm

Table 3
Electricity Billing Data

ELECTRIC USAGE SUMMARY			
Utility Provider:	JCP&L		
Rate:	GSS		
Meter No:	G15111585		
Customer ID No:	800376536		
Third Party Utility			
TPS Meter / Acct No:			
MONTH OF USE	**CONSUMPTION KWH**	**DEMAND**	**TOTAL BILL**
Jul-08	20,041	116.0	$3,284
Aug-08	19,328	122.0	$3,147
Sep-08	25,060	126.0	$3,540
Oct-08	36,361	126.0	$5,022
Nov-08	33,218	127.0	$4,641
Dec-08	44,666	134.0	$6,044
Jan-09	38,101	134.0	$5,473
Feb-09	33,280	125.0	$4,862
Mar-09	36,918	114.0	$5,314
Apr-09	28,402	114.0	$3,947
May-09	25,767	114.0	$3,573
Jun-09	11,736	100.0	$1,664
Totals	**352,878**	**134.0 Max**	**$50,511**
	AVERAGE DEMAND	**121.0 KW average**	
	AVERAGE RATE	**$0.143 $/kWh**	

Figure 1
Electricity Usage Profile

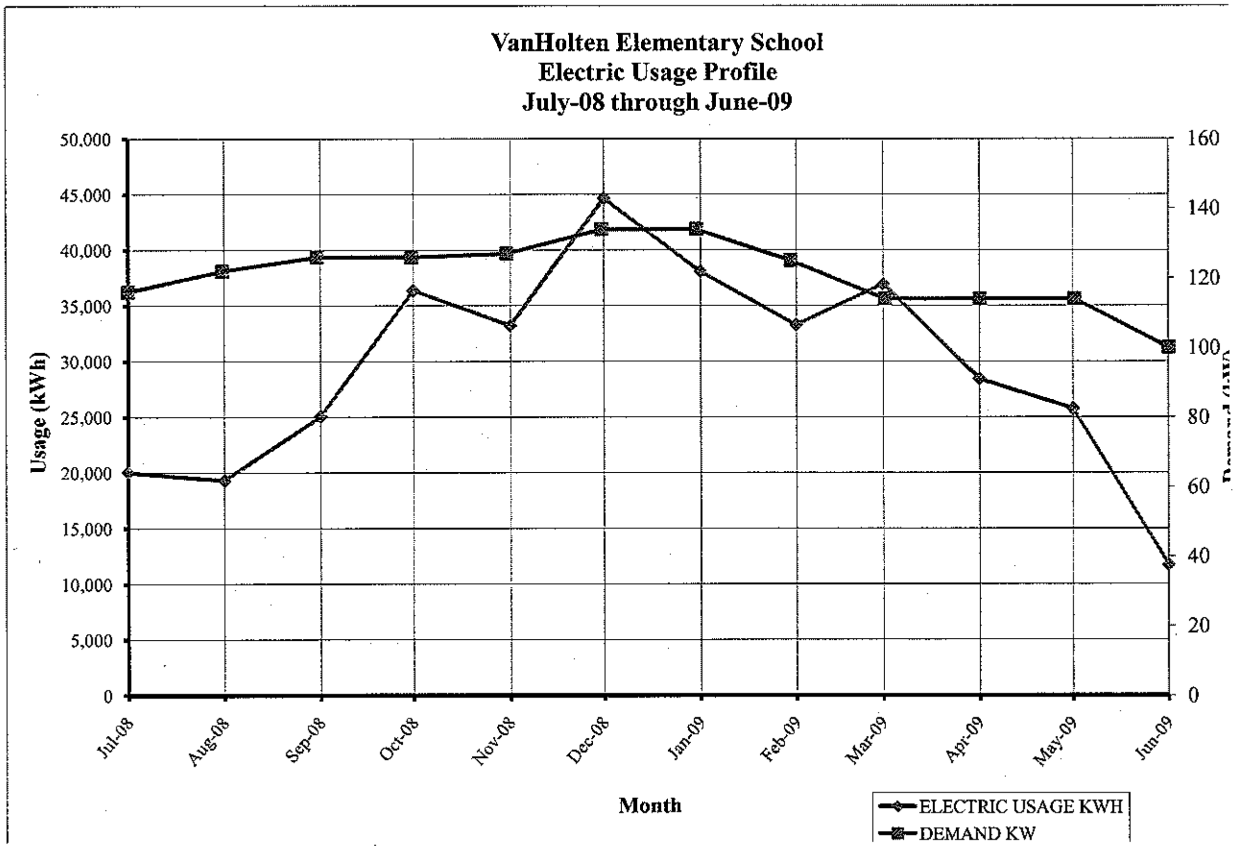
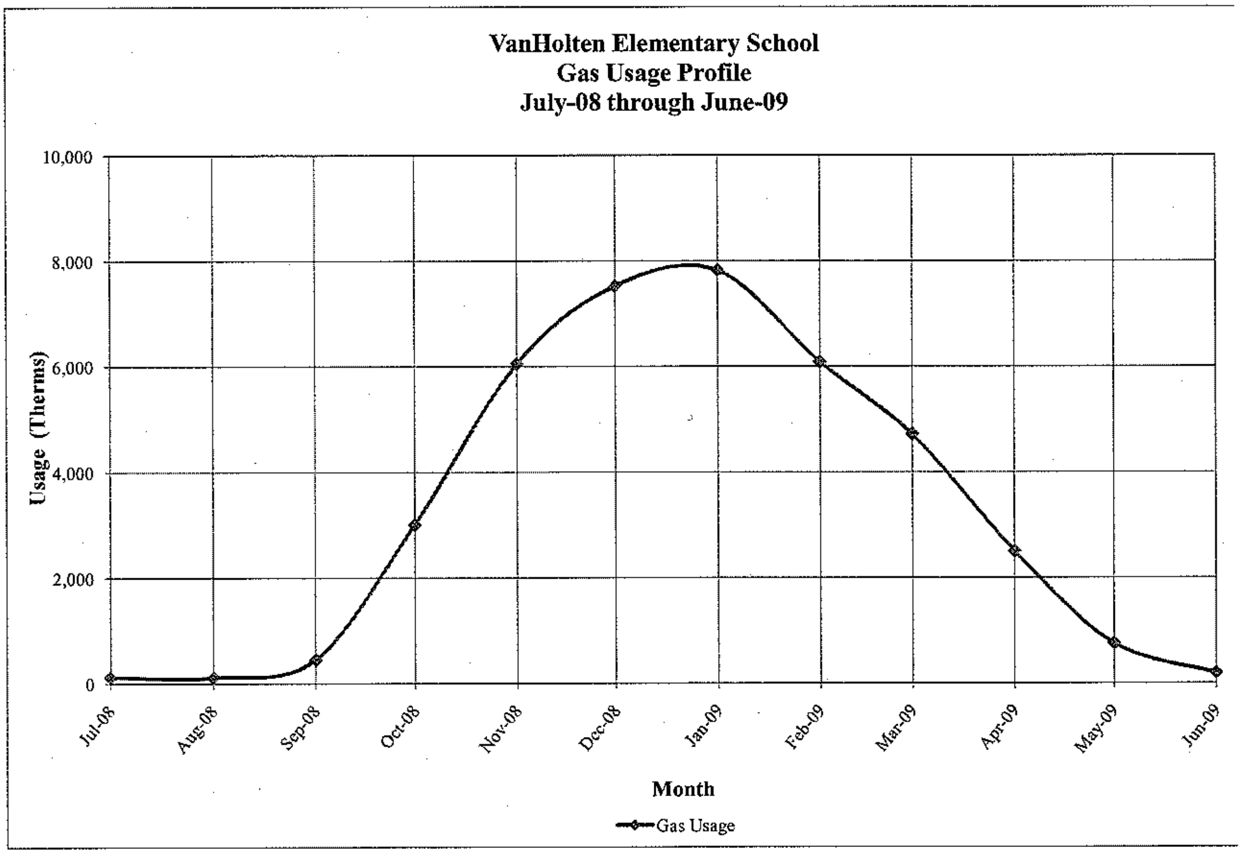


Table 4
Natural Gas Billing Data

NATURAL GAS USAGE SUMMARY		
Utility Provider:	PSE&G	
Rate:	LVG	
Meter No:	3010327	
Point of Delivery ID:	PG000008758668101933	
Third Party Utility Provider:	HESS	
TPS Meter No:	446567	
MONTH OF USE	**CONSUMPTION (THERMS)**	**TOTAL BILL**
Jul-08	121	$289
Aug-08	112	$253
Sep-08	452	$670
Oct-08	3,006	$4,535
Nov-08	6,050	$9,098
Dec-08	7,522	$11,213
Jan-09	7,823	$11,708
Feb-09	6,090	$9,172
Mar-09	4,718	$6,472
Apr-09	2,508	$3,214
May-09	754	$1,029
Jun-09	196	$326
TOTALS	**39,352**	**$57,979**
AVERAGE RATE:	**$1.473**	**$/THERM**

Figure 2
Natural Gas Usage Profile



B. Energy Use Index (EUI)

Energy Use Index (EUI) also known as "Energy Use Intensity," is a measure of a building's annual energy utilization per square foot of building. This calculation is completed by converting all utility usage consumed by a building for one year, to British Thermal Units (BTU) and dividing this number by the building square footage. EUI is a good measure of a building's energy use and is utilized regularly for comparison of energy performance for similar building types. The Oak Ridge National Laboratory (ORNL) Buildings Technology Center under a contract with the U.S. Department of Energy maintains a Benchmarking Building Energy Performance Program. The ORNL website determines how a building's energy use compares with similar facilities throughout the U.S. and in a specific region or state.

Source use differs from site usage when comparing a building's energy consumption with the national average. Site energy use is the energy consumed by the building at the building site only. Source energy use includes the site energy use as well as all of the losses to create and distribute the energy to the building. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, which allows for a complete assessment of energy efficiency in a building. The type of utility purchased has a substantial impact on the source energy use of a building. The EPA has determined that source energy is the most comparable unit for evaluation purposes and overall global impact. Both the site and source EUI ratings for the building are provided to understand and compare the differences in energy use.

The site and source EUI for this facility is calculated as follows:

$$Building\ Site\ EUI = \frac{(Electric\ Usage\ in\ kBtu + Gas\ Usage\ in\ kBtu)}{Building\ Square\ Footage}$$

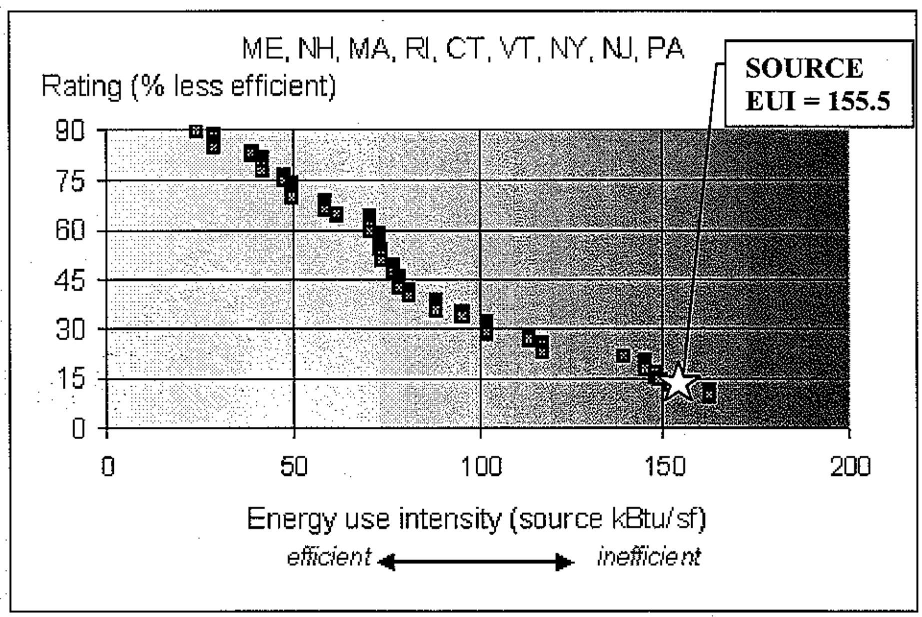
$$Building\ Source\ EUI = \frac{(Electric\ Usage\ in\ kBtu\ X\ SS\ Ratio + Gas\ Usage\ in\ kBtu\ X\ SS\ Ratio)}{Building\ Square\ Footage}$$

Table 5
Facility Energy Use Index (EUI) Calculation

ENERGY USE INTENSITY CALCULATION						
ENERGY TYPE	BUILDING USE			SITE ENERGY	SITE-SOURCE RATIO	SOURCE ENERGY
	kWh	Therms	Gallons	kBtu		kBtu
ELECTRIC	352878.0			1,204,725	3.340	4,023,783
NATURAL GAS		39352.0		3,935,200	1.047	4,120,154
FUEL OIL			0.0	0	1.010	0
PROPANE			0.0	0	1.010	0
TOTAL				5,139,925		8,143,938
*Site - Source Ratio data is provided by the Energy Star Performance Rating Methodology for Incorporating Source Energy Use document issued Dec 2007.						
BUILDING AREA		52,382	SQUARE FEET			
BUILDING SITE EUI		*98.12*	kBtu/SF/YR			
BUILDING SOURCE EUI		*155.47*	kBtu/SF/YR			

Figure 3 below depicts a national EUI grading for the source use of Elementary Schools.

Figure 3
Source Energy Use Intensity Distributions: Elementary Schools



C. EPA Energy Benchmarking System

The United States Environmental Protection Agency (EPA) in an effort to promote energy management has created a system for benchmarking energy use amongst various end users. The benchmarking tool utilized for this analysis is entitled Portfolio Manager. The Portfolio Manager tool allows tracking and assessment of energy consumption via the template forms located on the ENERGY STAR website (www.energystar.gov). The importance of benchmarking for local government municipalities is becoming more important as utility costs continue to increase and emphasis is being placed on carbon reduction, greenhouse gas emissions and other environmental impacts.

Based on information gathered from the ENERGY STAR website, Government agencies spend more than $10 billion a year on energy to provide public services and meet constituent needs. Furthermore, energy use in commercial buildings and industrial facilities is responsible for more than 50 percent of U.S. carbon dioxide emissions. It is vital that local government municipalities assess facility energy usage, benchmark energy usage utilizing Portfolio Manager, set priorities and goals to lessen energy usage and move forward with priorities and goals.

In accordance with the Local Government Energy Audit Program, an ENERGY STAR rating is analyzed for the facility to compare the facility to similar building types. The login page for the account can be accessed at the following web address:

https://www.energystar.gov/istar/pmpam/index.cfm?fuseaction=login.login

The utility bills and other information gathered during the energy audit process are entered into the Portfolio Manager. The following is a summary of the results for the facility:

Table 6
ENERGY STAR Performance Rating

ENERGY STAR PERFORMANCE RATING		
FACILITY DESCRIPTION	**ENERGY PERFORMANCE RATING**	**NATIONAL AVERAGE**
Van Holten Elementary School	37	50

Refer to **Statement of Energy Performance Appendix** for the detailed energy summary.

V. FACILITY DESCRIPTION

The 52,382 SF Elementary School is a single story facility comprised of classrooms, offices, multi-purpose room / cafeteria, kitchen, gymnasium, and library. The building was built in 1963 with the addition of a new classroom wing in 1999 and gymnasium in 2005. The typical school hours are between 8:30 am and 3:00 pm. The building construction is CMU block with face brick. The exterior walls have minimal insulation typical of the time period. It is unknown if the CMU blocks are filled with any form of insulation. The windows throughout the facility are single pane metal framed windows. The windows are casement style operable windows in fair condition. Due to its age, the windows do not seal well and are prone to leakage. The envelope in the additions has double pane windows with aluminum frames. The windows throughout the additions are double pane, with clear glass and aluminum frames in good condition. Blinds are installed on the inside of most windows. The building construction has a horizontal overhang approximately 2' around the building for shading. The roof is a flat roof with tar and crushed stone topping. The gymnasium has a flat roof with shingle sheathing. Roof insulation is above the metal deck. The amount of insulation below the roof membrane is unknown. Most doorways into the school are double doors with aluminum frames. Weather stripping is either missing or in poor condition in the existing portion of the building. The main entrance to the school opens to a lobby without a vestibule or separation from the rest of the building.

HVAC Cooling / Ventilation Systems

The building does not have central cooling in the original part of the building. The offices are cooled by window air conditioners. These units range from poor condition to new due to replacements as needed. Approximately 25% of the building is air conditioned. Some of the building such as the classrooms utilizes oscillating fans for air circulation in lieu of mechanical cooling. The classroom addition is heated and cooled by a packaged variable air volume rooftop unit with VAV boxes for zone control. These units are in good condition.

HVAC Heating Systems

Heating is provided by two gas fired fire-tube boilers made by Cleaver Brooks. The boilers were built in 1963. Each boiler has input capacity of 2,511 MBH. The boilers are in fair to poor condition, however well maintained for the age. Remaining life of the boilers is limited. The boilers produce hot water which is circulated throughout the building by two end suction heating water pumps (operating and standby). The boiler loop pumps are constant volume pumps. Classrooms are heated with baseboard radiators and unit ventilators. The unit ventilators and radiators appear to be in fair to poor condition. The heat is regulated by local room thermostats. The thermostats are old and in many cases not functioning properly. These rooms have trouble maintaining temperature resulting in under and over-heating spaces. A small percentage of rooms have had thermostats replaced due to uncontrollability and these rooms are controlling space temperature more consistently.

The additions are heated by rooftop units. The rooftop units provide heat via its gas fired heat exchangers. The rooftop gas heat is utilized as the sole source of heat for the gymnasium. The addition classrooms and hallways utilize the rooftop gas heat only in unoccupied periods. The existing building boilers provide heating hot water to reheat coils in the VAV boxes. The systems in the classroom addition and gymnasium are in good condition.

Exhaust System

Air is exhausted from the toilet rooms through roof exhausters. The exhaust fans in the original portion of the building are manually controlled by maintenance personnel through manual switching. The classroom addition and gymnasium is scheduled on and off by the district wide central DDC control system.

HVAC System Controls

The HVAC systems in the older portion of the facility are controlled through a manual control switchboard made by Barber Colman. Some equipment such as exhaust fans, and pumps have the capability to be controlled by time clocks, but these controls are not used and manual on / off switches are utilized instead. Individual room temperatures are controlled with local thermostats. These thermostats are in poor condition, (except for the thermostats that have been replaced.) Heating hot water flow is regulated by hydronic control valves within each space. The condition of the control valves is unknown. Temperature inconsistency in the heating season is a major concern for the building. It is unknown whether the uncontrollability is a result of thermostat or control valve operation. As a result of the lack of local control, the boiler operation is manually adjusted throughout the heating season.

The newer portion of the building including the classroom addition and gymnasium has a full DDC system with all system components wired back to a front end controller. The system has web access and remotely controlled by a district wide operations personnel. This system works well and provides reliable control of the components connected to the system.

Domestic Water

The domestic water for the building utilizes a booster pump to raise the supply pressure. The booster pumps were added as a result of the classroom addition. Since the distance from the domestic water service to the addition was deemed too far to provide adequate water pressure. The booster pumps are staged to maintain a pre-determined water pressure set point.

Domestic hot water for the restrooms lavatories, kitchen and various sinks is provided by a hot water storage tank heated indirectly through the boiler loop. Aqua stats control the boiler water circulator for domestic hot water heating. In addition to the indirect hot water heater, an independent self contained hot water heater is used for domestic hot water in the summer months to avoid operation of the boilers. The independent hot water heater is a 62 gallon gas fired hot water heater made by Ruud. The hot water heater is in fair condition.

Lighting

Lighting throughout the building is fluorescent tube lay-in fixtures with T-8 lamps and electronic ballasts. There are a few storage rooms and closets lit with compact fluorescent lamps. All lighting throughout the building is manually controlled by wall switches. Exterior lighting consists of wall mounted metal halide and high pressure sodium fixtures. The parking lot is lit with light poles with high pressure sodium lamps. Exterior lights are controlled by photocell / time clock controls.

VI. MAJOR EQUIPMENT LIST

The equipment list is considered major energy consuming equipment and through energy conservation measures could yield substantial energy savings. The list shows the major equipment in the facility and all pertinent information utilized in energy savings calculations. An approximate age was assigned to the equipment in some cases if a manufactures date was not shown on the equipment's nameplate. The ASHRAE service life for the equipment along with the remaining useful life is also shown in the Appendix.

Refer to the **Major Equipment List Appendix** for this facility.

VII. ENERGY CONSERVATION MEASURES

ECM #1: Lighting Controls

Description:

In some areas the lighting is left on unnecessarily. In many cases the lights are left on because of the inconvenience to manually switch lights off when a room is left or on when a room is first occupied. This is common in rooms that are occupied for only short periods and only a few times per day. In some instances lights are left on due to the misconception that it is better to keep the lights on rather than to continuously switch lights on and off. Although increased switching reduces lamp life, the energy savings outweigh the lamp replacement costs. The payback timeframe for when to turn the lights off is approximately two minutes. If the lights are expected to be off for at least a two minute interval, then it pays to shut them off.

Lighting controls come in many forms. Sometimes an additional switch is adequate to provide reduced lighting levels when full light output is not needed. Occupancy sensors detect motion and will switch the lights on when the room is occupied. Occupancy sensors can either be mounted in place of a current wall switch, or on the ceiling to cover large areas. Photocell control senses light levels and turn off or reduce lights when there is adequate daylight. Photocells are mostly used outside, but are becoming more popular in energy-efficient interior lighting designs as well.

The U.S. Department of Energy sponsored a study to analyze energy savings achieved through various types of building system controls. The referenced savings is based on the "Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways," document posted for public use April 2005. The study has found that commercial buildings have the potential to achieve significant energy savings through the use of building controls. The average energy savings are as follows based on the report:

- Occupancy Sensors for Lighting Control - 20%-28%.

Energy savings achieved for "Occupancy Sensors for Lighting Control" average 20%-28%. Savings resulting from the implementation of this ECM for energy management controls are estimated to be 10% of the total light energy controlled by occupancy sensors. The estimated savings is below the average listed above due to the continuous occupancy nature of school classrooms. The majority of the savings is expected to be after school hours when rooms are left with lights on.

The ECM includes replacement of standard wall switches with sensors wall switches for individual all offices, class rooms, and bathrooms. Sensors shall be manufactured by Sensorswitch, Watt Stopper or equivalent. See the "Investment Grade Lighting Audit" appendix for details.

The **Investment Grade Lighting Audit Appendix** of this report includes the summary of lighting controls implemented in this ECM and outlines the proposed controls, costs, savings, and payback periods. The calculations adjust the lighting power usage by 10% for all areas that include occupancy sensors.

Light Energy = 112,748 kWh/Yr. proposed lighting controlled energy

Est. Hours of Operation:

Classrooms:	1880 Hrs per year.
Hallways:	3150 Hrs per year.
Storage rooms and janitor closets:	470 Hrs per year.
Outdoor Lighting:	3650 Hrs per year.

Energy Savings Calculations:

$$Energy\ Savings = (10\% \times Occuapancy\ Sensored\ Light\ Energy\ (kWh / Yr))$$

$$Energy\ Savings = (10\% \times 112{,}748\ (kWh)) = 11{,}275\ (kWh)$$

$$Savings. = Energy\ Savings\ (kWh) \times Ave\ Elec\ Cost\left(\frac{\$}{kWh}\right)$$

$$Savings. = 11{,}275\ (kWh) \times 0.143\left(\frac{\$}{kWh}\right) = \$1{,}612$$

Installation cost per dual-technology sensor (Basis: Sensor switch or equivalent) is $75/unit including material and labor.

Installation Cost = $110 x 64 motion sensors = $7,040

From the NJ Smart Start appendix, the installation of a lighting control device warrants the following incentive: occupancy = $20 per fixture.

Smart Start® $Incentive = (\#\ of\ \ wall\ mount\ devices \times\ \$\,20) = (64 \times \$20) = \$1{,}280$

Energy Savings Summary:

ECM #1 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$7,040
NJ Smart Start Equipment Incentive ($):	$1,280
Net Installation Cost ($):	$5,760
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$1,612
Total Yearly Savings ($/Yr):	$1,612
Estimated ECM Lifetime (Yr):	15
Simple Payback	3.6
Simple Lifetime ROI	319.8%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$24,180
Internal Rate of Return (IRR)	27%
Net Present Value (NPV)	$13,483.95

ECM #2: Window Replacements

Description:

The windows in the original building of Van Holten Elementary School are single pane metal framed windows. These windows are below today's standards in insulation value and solar heat reflectivity. The age of the windows contribute to the leakage rate of the building. These factors lead to increased energy use primarily in the heating season. The increased cooling energy as a result of poor window performance is minimal. The heating loss due to single pane glass in combination with poor seals for each operable window can result in increased energy consumption.

This ECM includes the replacement of all existing windows in the original portion of the building with double pane windows and low emissivity glass. The proposed windows will includes smaller operable openings to minimize outside air leakage. In addition the double pane structure will significantly increase the insulation value compared to the existing single pane window structure.

Energy Savings Calculations:

$$Infiltration\left(\frac{Ft^3}{Min.}\right)=\frac{Area\left(Ft^2\right)\times Ave\ Height(Ft)\times AirChanges\ Per\ Hour\left(\frac{1}{Hr.}\right)}{60\left(\frac{Min}{Hr.}\right)}$$

$$Heat\ Load\left(\frac{Btu}{Hr.}\right)=1.1\times Infiltration\left(\frac{Ft^3}{Min}\right)\times Design\ Temperature\ Difference\ (^\circ F)$$

$$Leakage\ Energy\ (Therms)=\frac{Heat\ Load\left(\frac{Btu}{Hr.}\right)\times HDD(Day\ ^\circ F)\times 24\left(\frac{Hr.}{Day}\right)\times(0.60)}{65(^\circ F)\times Fuel\ Heat\ Value\left(\frac{Btu}{Therm}\right)\times Heating\ Efficiency\ (\%)}$$

$$Conductive\ Energy\ (Therms)=\frac{U-Value\times Area\left(Ft^2\right)\times HDD(Day\ ^\circ F)\times 24\left(\frac{Hr.}{Day}\right)\times(0.60)}{65(^\circ F)\times Fuel\ Heat\ Value\left(\frac{Btu}{Therm}\right)\times Heating\ Efficiency\ (\%)}$$

$$Energy\ Cost=Total\ Energy(Therms)\times Ave\ Fuel\ Cost\left(\frac{\$}{Therm}\right)$$

ECM #2 WINDOW REPLACEMENT CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Description:	Large Operable Single Pane Windows	Double Pane Low-E Windows	
Bldg area with single pane windows (SF)	43,477	43,477	
Average Ceiling Height (Ft)	9	9	
Window (SF)	6,066	6,066	
U-Value (BTU/HR/SF*°F)	0.88	0.45	0.43
Average Leakage Rate Heating Season (Air Changes per Hr)	1.0	0.5	0.5
Heating System Efficiency (%)	75%	75%	
Heating Degree Days (HDD)	4,888	4,888	
Design Day Temp Diff (°F)	65	65	
Nat Gas Fuel Value (BTU/Therm)	100,000	100,000	
Heating Hrs Per Day (Hrs)	24	24	
Electric Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Leakage Gas Energy (Therms)	6,732	3,366	3,366
Conductive Gas Energy (Therms)	5,010	2,562	2,448
Total Gas Energy (Therms)	11,742	5,928	5,814
Electric Energy (kWh)	0	0	0
Electric Demand (KW)	0	0	0
Gas Energy Cost ($)	$17,261	$8,714	$8,547
Electric Energy Cost ($)	$0	$0	$0
Comments:	1. Proposed window U-value Based on ASHRAE 90.1 - 2007 energy		

Energy Savings Summary:

ECM #2 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$454,950
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$454,950
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$8,547
Total Yearly Savings ($/Yr):	$8,547
Estimated ECM Lifetime (Yr):	25
Simple Payback	53.2
Simple Lifetime ROI	-53.0%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$213,675
Internal Rate of Return (IRR)	-5%
Net Present Value (NPV)	($306,119.83)

ECM #3: Window AC Unit Replacement

Description:

The office area, faculty rooms, and select classrooms of the school is air conditioned by window mounted air conditioners. The efficiency and size of the window units vary due to continuous replacements throughout the years. The cooling efficiencies of packaged window AC units range from 8.0 EER for older units up to 11.5 EER for new energy efficient models. The existing unit capacities typically range from 0.5 tons to 1.5 tons per window unit. The efficiency of many of the existing units are below today's standards.

This ECM calculates the payback for a typical window unit replacement with a new high efficiency window air conditioner. The intent of this ECM is to benchmark the EER rating of an existing window AC unit that when replaced with a new air conditioner provides a payback within the life of the unit. The example will show a one ton window air conditioner with an efficiency of at least 10.8 EER. The ECM is based on a one ton GE window AC unit model # ASM12AK or equal.

This ECM shows a typical payback for replacement of an 8.0 EER window AC unit with a 10.8 EER unit. The savings from the energy cost reduction pays for the installation of the unit within the unit's expected life. This measure represents the EER threshold of (8.0) for when to replace any existing window AC units. Any window AC unit with an EER of 8.0 or less should be replaced.

Energy Savings Calculations:

$$EnergyUsage = \frac{Cooling(Tons) \times 12{,}000\left(\frac{Btu}{Ton\ hr}\right) \times Full\ Load\ Hrs.}{1000\left(\frac{Wh}{kWh}\right) \times EER\left(\frac{Btu}{Wh}\right)}$$

$$Demand = \frac{Energy\ Savings\ (kWh)}{Hrs\ of\ Cooling}$$

$$Cooling\ Cost = Energy\ Usage(kWh) \times Ave\ Electric\ Cost\left(\frac{\$}{kWh}\right)$$

ECM #3 WINDOW AC UNIT REPLACEMENT CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Existing Window AC Units	High Efficiency Window AC Units	
Number of Window AC Units	1	1	
Tonnage per Window AC Unit	1.0	1.0	
Efficiency (EER)	8.0	10.8	
Equivelent Full Load Cooling Hrs	800	800	
BTUs per Ton (Btu/Hr/Ton)	12000	12000	
Watts per Kilo Watts (W/KW)	1000	1000	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Gas Energy (Therms)	0	0	0
Electric Energy (kWh)	1,200	889	311
Electric Demand (KW)	1.5	1.1	0.4
Gas Energy Cost ($)	$0	$0	$0
Electric Energy Cost ($)	$172	$127	$44
COMMENTS:	Equivalent full load hours is based on ASHRAE fundamentals reference book. Proposed High Efficiency window AC Unit is based on GE model # ASM12AK		

Installation cost for typical 1 ton AC unit units is estimated to be $420 ($345 Materials).

From the NJ Smart Start® Program appendix, the packaged unit's replacement falls under the category "Unitary AC" and warrants an incentive based on efficiency (EER) at or above 11.0. Therefore no incentive is available for this unit.

Energy Savings Summary:

ECM #3 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$420
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$420
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$48
Total Yearly Savings ($/Yr):	$48
Estimated ECM Lifetime (Yr):	10
Simple Payback	8.8
Simple Lifetime ROI	14.3%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$480
Internal Rate of Return (IRR)	3%
Net Present Value (NPV)	($10.55)

ECM #4: H&V Control Valves and T-Stat Replacements

Description:

The school is heated by a boiler water loop circulating heating water to heating and ventilation units and baseboards throughout the building. Each zone, (typically individual rooms were zoned separately), has a thermostat controlling a heating water control valve. The existing thermostats and control valves provide poor control of the space temperature in many cases resulting in overheating or under heating the rooms. Rooms that do not have adequate heat require the entire system to be adjusted to maintain adequate temperature. Typically the system is adjusted by increasing / decreasing the heating loop temperature to provide adequate heat for the coldest spaces. As a result some spaces become overheated and windows are opened even during the cold winter months.

This ECM includes installation of new hydronic control valves for each zone as well as new electronic thermostats to replace the existing thermostats. The new electronic thermostats and control valves will accurately regulate heating water flow and eliminate over / under heating of the zones. The thermostats include programmability to allow the building to set back during unoccupied periods. The thermostats could be adjusted by the occupants, however overriding control would take place at each scheduled temperature change. This ECM is not a central control system. Each thermostat and control valve is independent and based on a one for one replacement of the existing equipment.

The U.S. Department of Energy sponsored a study to analyze energy savings achieved through various types of building system controls. The referenced savings is based on the "Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways," document posted for public use April 2005. The study has found that commercial buildings have the potential to achieve significant energy savings through the use of building controls. The average energy savings are as follows based on the report:

- Energy Management and Control System Savings - 5%-15%.

Energy savings achieved for "Energy Management and Control Systems," average 5%-15%. The savings resulting from the implementation of this ECM for new control valves and thermostat controls are estimated to be 10% of the total Heating energy cost for the facility.

Energy Savings Calculations:

$$\textit{Existing Heating Gas Usage} = \textit{Total Gas Use}(\textit{Therms}) - \textit{Est. Dom. HW \& Kitchen Use}(\textit{Therms})$$

$$\textit{Gas Usage} = \textit{Existing Heat Use}\ (\textit{Therms}) \times (100\% - \textit{Energy Savings}(\%)) \times \frac{\textit{Retrofit Area}(Ft^2)}{\textit{Total Area}(Ft^2)}$$

$$\textit{Energy Cost} = \textit{Total Energy}(\textit{Therms}) \times \textit{Ave Fuel Cost}\left(\frac{\$}{\textit{Therm}}\right)$$

ECM #4 H&V CONTROL VALVE AND T-STAT CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Existing System	New Control Valves and T-Stats	
Est. Hot Water & Kitchen Gas Usage per Month (Therms Averaged from summer usage)	143	143	
Total Hot Water & Kitchen Gas Usage (Therms)	1,716	1,716	
Existing Total Gas Usage per Utility Bills (Therms)	39,352	39,352	
Total Building Area (SF)	52,382	52,382	
Area with pneumatic controls valves and T-Stats (SF)	43,477	43,477	
Est. Savings (%)	0%	10%	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Gas Energy (Therms)	31,238	28,114	3,124
Electric Energy (kWh)	0	0	0
Electric Demand (KW)	0.0	0.0	0.0
Gas Energy Cost ($)	$45,920	$41,328	$4,592
Electric Energy Cost ($)	$0	$0	$0
COMMENTS:			

Installation cost for the control valves and thermostats for each heating and ventilation unit is estimated to be $2,000 per thermostat / control valve installation. The number of zones is based on one thermostat and control valve per classroom or office that is currently not controlled by the central electronic control system. The original pneumatic controls are utilized in the multipurpose room, offices, library, A-wing classrooms, and B-wing classrooms (Total 35 zones.)

Installation Cost = ($2,000 / Zone) x (35 existing zones) = $70,000 ($26,250 Materials)

Energy Savings Summary:

ECM #4 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$70,000
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$70,000
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$4,520
Total Yearly Savings ($/Yr):	$4,520
Estimated ECM Lifetime (Yr):	15
Simple Payback	15.5
Simple Lifetime ROI	-3.1%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$67,800
Internal Rate of Return (IRR)	0%
Net Present Value (NPV)	($16,040.53)

ECM #5: Boiler Controller

Description:

The existing boilers are 4-pass fire-tube boilers made by Cleaver Brooks. The boilers are well maintained, however far past their reliable life expectancy. The boilers are controlled via aqua stats and maintain a set temperature when operating. New boiler controls have more precise control of the burner fire-rate, cycling, on/off temperature settings, and modulation. New temperature controls provide improvement on combustion efficiency and thermal efficiency by reducing the number of burner cycles and optimizing boiler supply water temperature based on outdoor temperature. The controls provide an estimated efficiency increase equal to 2.5% for combustion efficiency, and 2.5% for building loop temperature control. Overall fuel to hot water annual boiler efficiency increase is estimated to be 5%.

This ECM includes installation of new boiler controls for the existing boilers. The boiler controls are adaptable to new boilers in the event of a replacement. The energy savings is applied to the entire facility heating load since the whole building utilizes the boiler loop for heat. The ECM is based on Cleaver Brooks "SysteMax" boiler controller. The total installation cost for the boiler controller is estimated to be $25,000 based on pricing from Cleaver Brooks.

Energy Savings Calculations:

$$Existing\ Heating\ Gas\ Usage = Total\ Gas\ Use(Therms) - Est.\ Dom.\ HW\ \&\ Kitchen\ Use(Therms)$$

$$Bldg\ Heat\ \mathrm{Re}quired = Existing\ Gas\ Use\ (Therms) \times Existing\ Heating\ Efficiency(\%)$$

$$Heating\ Gas\ Usage = \frac{Bldg\ Heat\ \mathrm{Re}quired\ (Therms)}{Heating\ Efficiency(\%)}$$

$$Energy\ Cost = Heating\ Gas\ Usage(Therms) \times Ave\ Fuel\ Cost\left(\frac{\$}{Therm}\right)$$

ECM #5 BOILER CONTROLLER CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Existing System	New Boiler Controller	
Est. Hot Water & Kitchen Gas Usage per Month (Therms Averaged from summer usage)	143	143	
Total Hot Water & Kitchen Gas Usage (Therms)	1,716	1,716	
Existing Total Gas Usage per Utility Bills (Therms)	39,352	39,352	
Heating System Efficiency	75%	80%	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Required Bldg Heat Energy (Therms)	28,227	28,227	0
Gas Energy (Therms)	37,636	35,284	2,352
Electric Energy (kWh)	0	0	0
Electric Demand (KW)	0.0	0.0	0.0
Gas Energy Cost ($)	$55,325	$51,867	$3,458
Electric Energy Cost ($)	$0	$0	$0
COMMENTS:			

Energy Savings Summary:

ECM #5 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$25,000
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$25,000
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$3,458
Total Yearly Savings ($/Yr):	$3,458
Estimated ECM Lifetime (Yr):	15
Simple Payback	7.2
Simple Lifetime ROI	107.5%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$51,870
Internal Rate of Return (IRR)	11%
Net Present Value (NPV)	$16,281.38

ECM #6: DDC System Controls

Description:

The school is divided into two different sections; original building and addition. The original building is controlled with local controls through an old electronic control board. The equipment in the additions is controlled by a central DDC control system. This system is supported by digital controls with remote access capability. The original building thermostats and control valves provide poor control of the space temperature in many cases resulting in overheating or under heating the rooms. The existing system in the original building does not have the capability to optimize temperature control with the central system. There is no programmable function in the existing system to integrate equipment together for optimized efficiency. Controls that provide adjustment for outdoor conditions, time of day, and occupied / unoccupied modes, either do not exist on the existing system or have been abandoned due to inconsistency and unreliability. New temperature sensors and electronic control valves tied into a new digital control systems have the capability of saving significant energy as well as improve occupant comfort.

This ECM includes installing a Building Automation system through Direct Digital Controls (DDC) wired through an Ethernet backbone and front end controller. The system will include new thermostat controllers for terminal unit ventilators, baseboard zones, and air handling units wired back to a front end controller with computer interface. The front end device will provide communication between the devices as well as the main boilers and pumps. The system will respond to the overall building's needs and operating schedules as defined by the building operator. The DDC system provides features such as space averaging, temperature override control, night set-back, morning warm-up mode, heating water loop temperature re-set, etc. The ECM includes replacing all existing controls and control valves with new electronic actuated control valves integrated into the control system.

The U.S. Department of Energy sponsored a study to analyze energy savings achieved through various types of building system controls. The referenced savings is based on the "Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways," document posted for public use April 2005. The study has found that commercial buildings have the potential to achieve significant energy savings through the use of building controls. The average energy savings are as follows based on the report:

- Energy Management and Control System Savings - 5%-15%.

Energy savings achieved for "Energy Management and Control Systems," average 5%-15%. The savings resulting from the implementation of this ECM for new a DDC system is estimated to be 15% of the total heating and cooling energy cost for the facility. The savings is estimated to be at the maximum range of the report due to the extreme lack of control with the existing system, as well as the added programmable functionality of the full digital control system integrating all equipment for optimal performance.

Energy Savings Calculations:

Heating Energy:

$$Existing\ Heating\ Gas\ Usage = Total\ Gas\ Use(Therms) - Est.\ Dom.\ HW\ \&\ Kitchen\ Use(Therms)$$

$$Gas\ Usage = Existing\ Heat\ Use\ (Therms) \times (100\% - Energy\ Savings(\%)) \times \frac{\mathrm{Re}trofit\ Area(Ft^2)}{Total\ Area(Ft^2)}$$

$$Energy\ Cost = Total\ Gas\ Usage(Therms) \times Ave\ Fuel\ Cost\left(\frac{\$}{Therm}\right)$$

Cooling Energy:

$$EnergyUsage = \frac{Cooling(Tons) \times 12{,}000\left(\frac{Btu}{Ton\ hr}\right) \times Full\ Load\ Hrs.}{1000\left(\frac{Wh}{kWh}\right) \times EER\left(\frac{Btu}{Wh}\right)} \times (1 - Savings(\%))$$

$$Cooling\ Cost = Energy\ Usage(kWh) \times Ave\ Electric\ Cost\left(\frac{\$}{kWh}\right)$$

ECM #6 DDC CONTROLS CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Existing System	DDC Control System	
Est. Hot Water & Kitchen Gas Usage per Month (Therms Averaged from summer usage)	143	143	
Total Hot Water & Kitchen Gas Usage (Therms)	1,716	1,716	
Existing Total Gas Usage per Utility Bills (Therms)	39,352	39,352	
Total Building Area (SF)	52,382	52,382	
Area with old control valves and T-Stats (SF)	43,477	43,477	
Total AC Unit Tonnage (Tons)	0.0	0.0	
Average AC Unit Efficiency (EER)	8.0	8.0	
Equivelent Full Load Cooling Hrs	800	800	
Est. Savings	0%	15%	15%
BTUs per Ton (Btu/Hr/Ton)	12000	12000	
Watts per Kilo Watts (W/KW)	1000	1000	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Gas Energy (Therms)	31,238	26,552	4,686
Electric Energy (kWh)	0	0	0
Electric Demand (KW)	0.0	0.0	0.0
Gas Energy Cost ($)	$45,920	$39,032	$6,888
Electric Energy Cost ($)	$0	$0	$0
COMMENTS:			

The cost of a full DDC system with new field devices, controllers, computer, software, programming, etc. is approximately $3,500 per zone or H&V unit controlled and $15,000 for boiler and pump controls. Savings from the implementation of this ECM will be achieved through reduced gas consumption from reduced heating energy.

Cost of complete DDC System = ($3,500/Unit x 35 Units) + $15,000 for boiler and pump controls = $137,500.

Energy Savings Summary:

ECM #6 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$137,500
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$137,500
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$6,888
Total Yearly Savings ($/Yr):	$6,888
Estimated ECM Lifetime (Yr):	15
Simple Payback	20.0
Simple Lifetime ROI	-24.9%
Simple Lifetime Maintenance Savings	0
Simple Lifetime Savings	$103,320
Internal Rate of Return (IRR)	-3%
Net Present Value (NPV)	($55,271.50)

ECM #7: Pump VFDs

Description:

The distribution of the heating water throughout the original facility is through two 5HP pumps. The heating water is distributed to the building's baseboard radiators and H&V units. The terminal equipment currently has 3-way control valves, which diverts the water flow around the unit when there is no call for heat. The total flow rate of heating water that the pumps provide is 100% of the pumps capacity. A 2-way control valve will stop water flow when the terminal unit is not calling for heat. As the control valve on the H&V units modulate, the VFDs slow the pump motor to match the building's load. This allows the total flow of the system to be reduced when less than 100% of the units are calling for heat. A variable frequency drive (VFD) in combination with 2-way control valves throughout the building slows the pump down in when the terminal units close their control valve. The VFD uses the minimum required amount of electricity to pump only as much water that is needed for the building.

This ECM includes the installation of two new variable frequency drives (VFDs) for the two 5 HP base mounted heating water pumps. This ECM is based on two ABB VFDs model number ACS350, as well as a differential pressure sensor installed in the heating water piping. This ECM is based on converting the existing 3-way control valves to 2-way control valves through the implementation of ECM #4 or ECM #6. These ECMs already include control valve replacements and the cost associated. The Pump VFD installation cost does not include the cost of replacing control valves and must be combined with ECM #4 or ECM #6. The energy and cost savings for these specific combinations of ECMs is additive.

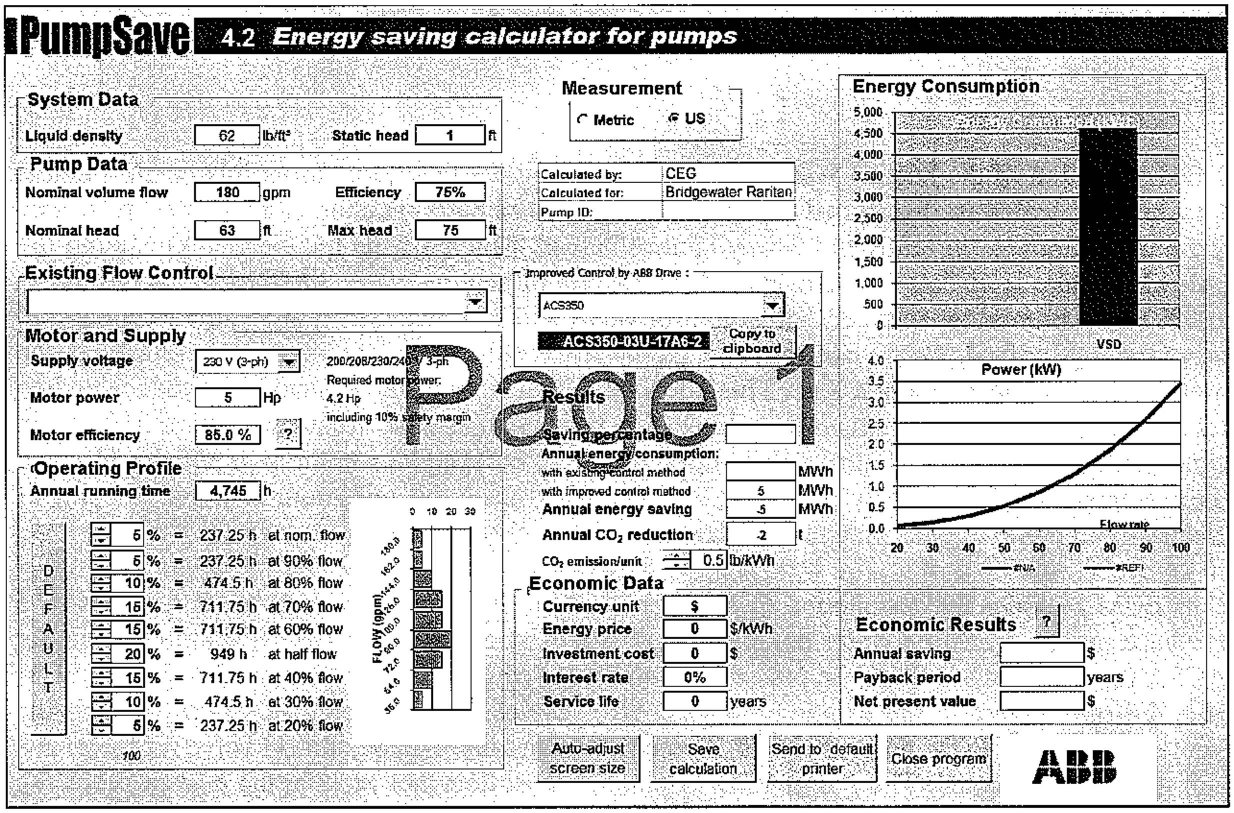
Energy and cost savings calculations are based on calculation software "PumpSave v4.2," provided by ABB. The heating pump operation is estimated to be 4745 Hrs per year (6.5 months).

Energy Savings Calculations:

$$Cons.\ Volume\ Power(HP) = \frac{Specific\ Gravity \times Flow\ Rate\left(\frac{Gal}{\min}\right) \times Head(Ft)}{3960 \times Pump\ Efficiency(\%) \times Motor\ Efficiency(\%)}$$

$$Energy\ Cons.\ (kWh) = Power(HP) \times 0.746\left(\frac{KW}{HP}\right) \times Operation(Hrs.)$$

$$Energy\ Cost = Energy\ Usage(kWh) \times Ave\ Electric\ Cost\left(\frac{\$}{kWh}\right)$$


PumpSave 4.2 Energy saving calculator for pumps
System Data
Liquid density 62 lb/ft³
Static head 1 ft
Pump Data
Nominal volume flow 180 gpm
Efficiency 75%
Nominal head 63 ft
Max head 75 ft
Existing Flow Control
Motor and Supply
Supply voltage 230 V (3-ph)
200/208/230/240 V 3-ph
Required motor power:
4.2 Hp
including 10% safety margin
Motor power 5 Hp
Motor efficiency 85.0 %
Operating Profile
Annual running time 4,745 h
DEFAULT
5 % = 237.25 h at nom. flow
5 % = 237.25 h at 90% flow
10 % = 474.5 h at 80% flow
15 % = 711.75 h at 70% flow
15 % = 711.75 h at 60% flow
20 % = 949 h at half flow
15 % = 711.75 h at 40% flow
10 % = 474.5 h at 30% flow
5 % = 237.25 h at 20% flow
100
FLOW (gpm)
Measurement
Metric
US
Calculated by: CEG
Calculated for: Bridgewater Raritan
Pump ID:
Improved Control by ABB Drive :
ACS350
ACS350-03U-17A6-2
Copy to clipboard
Page 1
Results
Saving percentage
Annual energy consumption:
with existing control method MWh
with improved control method 5 MWh
Annual energy saving -5 MWh
Annual CO₂ reduction -2 t
CO₂ emission/unit 0.5 lb/kWh
Economic Data
Currency unit $
Energy price 0 $/kWh
Investment cost 0 $
Interest rate 0%
Service life 0 years
Energy Consumption
VSD
Power (kW)
Flow rate
Economic Results
Annual saving $
Payback period years
Net present value $
Auto-adjust screen size
Save calculation
Send to default printer
Close program
ABB

ECM #7 PUMP VFD CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Constant Volume Pumps	VFD Pumps	
Flow (GPM)	180	180	
Head (Ft)	63	63	
Pump Efficiency (%)	75%	75%	
Motor Efficiency (%)	85%	85%	
Heating Operating Hrs	4745	4745	
KW per HP (KW/HP)	0.746	0.746	
HP Equation Constant (W/KW)	3960	3960	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Gas Energy (Therms)	0	0	0
Electric Energy (kWh)	15,901	4,600	11,301
Electric Demand (KW)	0.0	0.0	0.0
Gas Energy Cost ($)	$0	$0	$0
Electric Energy Cost ($)	$2,274	$658	$1,616
COMMENTS:	VFD pump energy is based on ABB energy savings calculator for pumps, "Pump Save," version 4.2. Flow rate for VFD Pump calculation is summarized in the operating profile shown in the Pump Save output.		

Installation cost for the two VFDs is estimated to be $5,150 ($3,400 Materials).

Energy Savings Summary:

ECM #7 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$5,150
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$5,150
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$1,616
Total Yearly Savings ($/Yr):	$1,616
Estimated ECM Lifetime (Yr):	15
Simple Payback	3.2
Simple Lifetime ROI	370.7%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$24,240
Internal Rate of Return (IRR)	31%
Net Present Value (NPV)	$14,141.70

Note: This ECM (Pump VFD) is based on the implementation of ECM#4 "H&V control valves and Thermostats," or ECM#6 "DDC Controls." These ECMs include control valve replacements, which requires 2-way control valves in lieu of the existing 3-way control valves. The energy and cost savings for these specific combinations of ECMs is additive.

ECM #8: Combining ECM#4, & ECM#7

Description:

The following savings summary is the simultaneous implementation of the H&V unit control valves and Thermostats as well and the implementation of the Pump VFD. The pump VFD is depended on replacing the existing 3-way control valves with 2-way control valves for variable flow energy savings. The following is the financial summary if both ECMs were implemented together:

Energy Savings Summary:

ECM #8 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$75,150
NJ Smart Start Equipment Incentive ($):	$0
Net Installation Cost ($):	$75,150
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$6,136
Total Yearly Savings ($/Yr):	$6,136
Estimated ECM Lifetime (Yr):	15
Simple Payback	12.2
Simple Lifetime ROI	22.5%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$92,040
Internal Rate of Return (IRR)	3%
Net Present Value (NPV)	($1,898.83)

ECM #9: Condensing Boiler

Description:

The building boilers are utilized in an operating and standby mode. Only one boiler is utilized at a time and the other boiler is a backup. The boilers are cycled to even runtime, however only one boiler is needed to satisfy the load. The existing boilers are far past the life expectancy of typical fire-tube boiler, however they are well maintained for their age and both boilers are in operating condition. Multiple tubes are being replaced on an annual basis, which indicates corrosion taking place in the pressure vessel. Although the boilers are close to the end of their life cycle it is difficult to predict the point at which the boiler becomes inoperable.

New condensing boilers could substantially improve the operating efficiency of the heating system of the building. Condensing boiler's peak efficiency tops out at 99% depending on return water temperature. Due to the operating conditions of the building, the annual average operating efficiency is expected to be 89.5%. This is approximately 15% increase in efficiency over the existing boilers. This ECM is based on replacing one of the two existing boilers. The existing boiler can remain as a backup for the new boiler.

This ECM includes installation of one condensing gas fired boiler to replace one of the existing steel fire-tube boilers. The boiler installation includes the SysteMax boiler controls for the boiler burner control and firing rate, outdoor temperature reset, etc. The basis for this ECM is the Clear Fire boilers made by Cleaver Brooks, model number CFC-2500. The boiler installation is based on a one for one replacement of the existing boiler. The ECM is based on replacing only one boiler to minimize installation cost.

Energy Savings Calculations:

$$Existing\ Heating\ Gas\ Usage = Total\ Gas\ Use(Therms) - Est.\ Dom.\ HW\ \&\ Kitchen\ Use(Therms)$$

$$Bldg\ Heat\ \mathrm{Re}quired = Existing\ Gas\ Use\ (Therms) \times Existing\ Heating\ Efficiency(\%)$$

$$Heating\ Gas\ Usage = \frac{Bldg\ Heat\ \mathrm{Re}quired\ (Therms)}{Heating\ Efficiency(\%)}$$

$$Energy\ Cost = Heating\ Gas\ Usage(Therms) \times Ave\ Fuel\ Cost\left(\frac{\$}{Therm}\right)$$

ECM #9 CONDENSING BOILER CALCULATIONS			
ECM INPUTS	**EXISTING**	**PROPOSED**	**SAVINGS**
ECM INPUTS	Existing System	New Boiler Controller	
Est. Hot Water & Kitchen Gas Usage per Month (Therms Averaged from summer usage)	143	143	
Total Hot Water & Kitchen Gas Usage (Therms)	1,716	1,716	
Existing Total Gas Usage per Utility Bills (Therms)	39,352	39,352	
Heating System Efficiency	75%	89.5%	
Elec Cost ($/kWh)	0.143	0.143	
Gas Cost ($/Therm)	1.47	1.47	
ENERGY SAVINGS CALCULATIONS			
ECM RESULTS	**EXISTING**	**PROPOSED**	**SAVINGS**
Required Bldg Heat Energy (Therms)	28,227	28,227	0
Gas Energy (Therms)	37,636	31,539	6,097
Electric Energy (kWh)	0	0	0
Electric Demand (KW)	0.0	0.0	0.0
Gas Energy Cost ($)	$55,325	$46,362	$8,963
Electric Energy Cost ($)	$0	$0	$0
COMMENTS:			

From the NJ Smart Start® Program appendix, the condensing boilers falls under the category "Gas Heating" and warrants an incentive based on efficiency at or above 84% AFUE. The program incentives are calculated as follows:

Smart Start® $Incentive = (Boiler\,MBH \times \$1/MBH)$

$= (2{,}500\,MBH \times \$1/MBH) = \$2{,}500$

Energy Savings Summary:

ECM #9 - ENERGY SAVINGS SUMMARY	
Installation Cost ($):	$72,500
NJ Smart Start Equipment Incentive ($):	$2,500
Net Installation Cost ($):	$70,000
Maintenance Savings ($/Yr):	$0
Energy Savings ($/Yr):	$8,963
Total Yearly Savings ($/Yr):	$8,963
Estimated ECM Lifetime (Yr):	25
Simple Payback	7.8
Simple Lifetime ROI	220.1%
Simple Lifetime Maintenance Savings	$0
Simple Lifetime Savings	$224,075
Internal Rate of Return (IRR)	12%
Net Present Value (NPV)	$86,074.04